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Man-made changes in south Florida threaten estuarine environments—home for a multimillion dollar fish industry.

Alterations of Estuaries of South Florida: A Threat to Its Fish Resources

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ABSTRACT

Based on unpublished data from 1966-1970, about 85 percent of the commercial fish and shellfish caught in south Florida consists of estuarine-dependent species. The annual harvest of these species averaged more than 36 million pounds worth in excess of $10 million (ex-vessel value). Data on the region's sport fishery are lacking, but it is estimated that the majority of the species taken by anglers are estuarine-dependent and responsible for about $575 million of the State's annual tourist industry. Man's alterations of the estuaries are threatening these fish resources. Some of the major alterations, reduction of freshwater runoff, domestic and industrial pollution, pesticide contamination, thermal addition, and dredging and filling, are discussed.

INTRODUCTION

The mangrove dominated bays and rivers of south Florida provide food and protective habitat for hundreds of marine species of fish and shellfish which occupy these areas as juveniles and are thus dependent on the brackish water zone for survival. Many of these species are harvested by commercial and sport fishermen and are worth several million dollars annually to Florida's economy. The burgeoning human population of south Florida with its attendant demands for housing, industrial, and agricultural development, however, is upsetting the ecological balance of the estuarine ecosystem, thereby threatening the estuarine-dependent species.

The purpose of this report is to define the importance of south Florida's estuarine ecosystem to the production of marine fish and shellfish, and to discuss some of the major threats to these resources.

COMMERCIAL FISHERY

Unpublished catch data were collated to show the location, magnitude, and value of south Florida's commercial fishery. For the purpose of depicting locations of the commercial fishing grounds, statistical subdivisions of the grounds with code numbers and names used by the National Marine Fisheries Service are shown in Figure 1. Catches within each statistical area for the latest five-year period of record (1966-1970) were analyzed to determine the percentage of the catch composed of estuarine-dependent species. This was accomplished by reviewing the literature on the life history of each species and listing the major species known to utilize estuarine waters during some phase of their life cycle, usually the early phase. Average annual harvests of these species were determined, subdivided into the categories "finfish" and "shellfish," and arranged in decreasing order by weight (Table 1). Annual harvest averaged more than 36.3 million pounds worth over $10 million and represented about 85 percent of the catch and value of all marine fishery resources taken commercially in south Florida during the five-year period. Striped mullet (*Mugil cephalus*) and pink shrimp (*Penaeus duorarum*) were the two major crops, representing 70 percent of the weight and 79 percent of the value.

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SPORT FISHERY

The results of Higman (1967, 1969), who reported on the quantity and species composition of fish caught in the Flamingo Area in 1959-1966 and 1969, are the only studies on sport fishing available for south Florida. Higman stated that the top three species preferred by fishermen in the area were spotted seatrout (*Cynoscion nebulosus*), gray snapper (*Lutjanus griseus*), and red drum (*Sciaenops ocellata*). All three are estuarine-dependent.

Reliable estimates of the value of the sport fishery are not available. A rough estimate can be obtained, however. McQuigg (1971), estimating that 31 percent of Florida's visitors come for the fishing, reported that sport fishing in the state was responsible for about $1.7 billion of the $5.5 billion tourist industry. Based on 33.8 percent of the state's "user occasion"—one instance of participation in saltwater sport fishing by one person—occurring in south Florida (Florida

Department of Natural Resources, 1971), I calculated that the south Florida sport fishery is responsible for about $575 million (33.8 percent of $1.7 billion) of the State's tourist industry. Therefore, sport fishing plays a significant role in south Florida's economy.

THREATS TO THE FISHERIES

Man-made changes in the natural environment of south Florida are creating myriad problems for those of us charged with the responsibility of protecting against over-exploitation and despoilment of living marine resources. Unquestionably, the majority of marine species important to man are inextricably linked to the estuarine environment, and because of the physiographic and hydrologic makeup of south Florida, the estuarine ecosystem may be adversely affected by changes many miles inland as well as by changes in the estuary proper. Some of the major changes and, therefore, threats to marine fishery production are discussed below.

Reduction of Freshwater Runoff

Freshwater runoff is one of the most important factors affecting south Florida's aquatic ecosystem. For example, Everglades National Park, which contains the majority of south Florida's estuarine area, is entirely dependent on freshwater flow from north of its boundaries (Tabb and Idyll, 1964). However, man has increasingly altered natural drainage patterns in the fertile wetlands and thereby reduced freshwater runoff to the estuaries. The following is a brief history of these alterations taken from Tabb (1963, 1966), Idyll (1965, 1969), and Heald (1970).

Originally the watershed of south Florida's estuaries extended as far north as Ocala in central Florida and covered about 9,000 square miles.

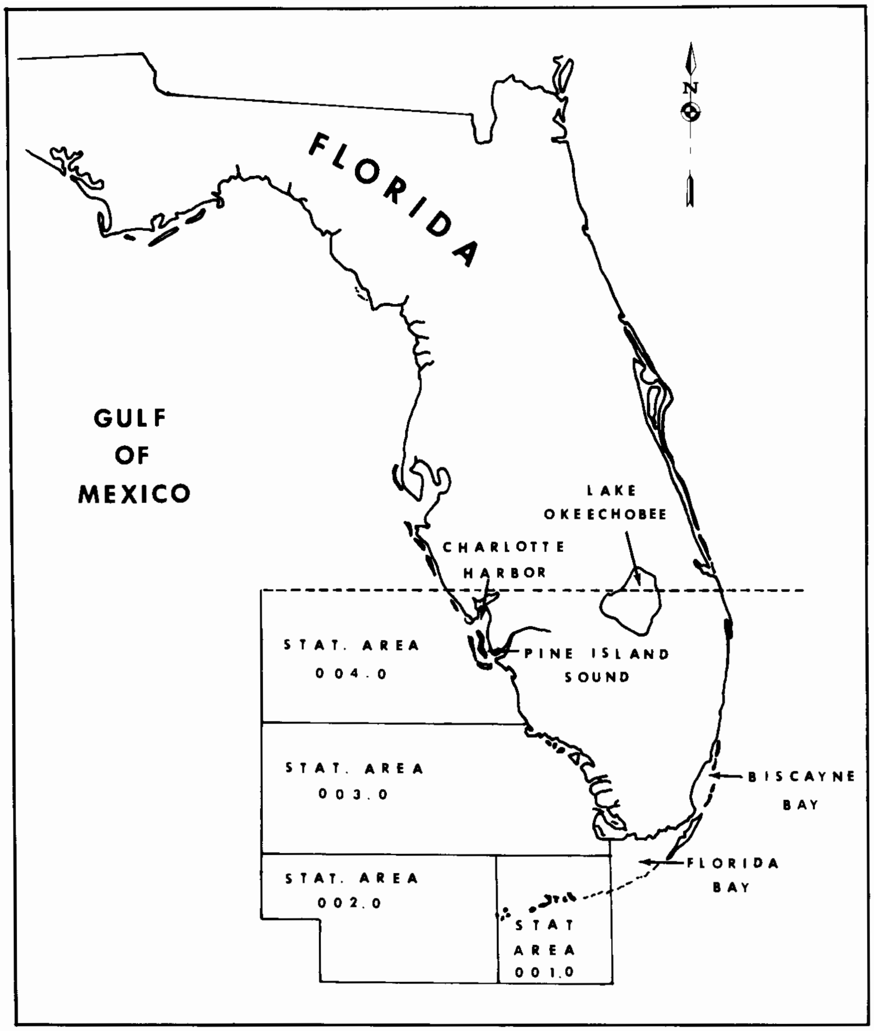


Figure 1.—Statistical subdivisions of south Florida fishing grounds.

Canal and levee construction for land reclamation and flood control purposes began in the 1880's and has been almost continuous since that time. The most drastic changes in freshwater flow came in the 1920's with construction of numerous canals draining into the Atlantic Ocean. In 1930 a dike was begun around Lake Okeechobee to prevent a recurrence of overflow from hurricanes such as the one in 1928 which killed an estimated 1,500-2,000 people. Additions are still being made.

With the creation of the Central and South Florida Flood Control District (FCD) in 1949, more canals were dug, and extensive levees and water control structures were built. The Kissimmee River, the largest tributary to Lake Okeechobee, was channeled and straightened, and channels from the Lake were enlarged. This allowed millions of gallons of fresh water to drain into the Atlantic and Gulf before each hurricane season. Aware of the loss of fresh water needed to recharge the aquifer, the FCD built shallow water conservation areas, but the levees also blocked the natural sheet flow into the lower Everglades. By 1960 the original watershed of 9,000 square miles had been reduced to 3,000.

Table 1.—Major estuarine-dependent species taken commercially from estuarine and marine waters of south Florida—five year average (1966-1970)

Species	Stat. Area 001.0		Stat. Area 002.0		Stat. Area 003.0		Stat. Area 004.0		Charlotte Harbor		Pine Island Sound		Biscayne Bay		Total		Percentage of Grand Total	
	Pounds*	Value	Pounds*	Value	Pounds*	Value	Pounds*	Value	Pounds*	Value	Pounds*	Value	Pounds*	Value	Pounds*	Value	Pounds	Value
FINFISH+																	%	%
Striped mullet (*Mugil cephalus*)	7,500	664	1,300	104	1,035,000	72,228	4,263,500	329,895	1,257,100	100,159	2,465,300	205,963	12,420	1,565	9,042,120	710,578	24.85	6.98
Spanish mackerel (*Scomberomorus maculatus*)	1,371,600	160,374	296,000	34,393	512,700	58,570	1,027,600	119,154	27,000	2,990	57,900	6,772	18,740	2,254	3,311,540	384,507	9.10	3.78
Spotted seatrout (*Cynoscion nebulosus*)	103,200	32,373	9,000	2,676	70,700	21,339	584,300	167,646	81,400	22,868	651,100	184,395	9,040	3,182	1,508,740	434,479	4.15	4.27
White mullet (*Mugil curema*)	348,000	28,083	30,500	2,804	72,600	4,334	157,200	9,454	7,900	408	24,200	1,582	194,000	19,009	834,400	65,674	2.29	4.90
Florida pompano (*Trachinotus carolinus*)	132,800	110,907	41,700	33,061	55,000	45,108	231,600	202,584	9,900	7,429	93,900	86,218	15,140	13,217	580,040	498,524	1.59	4.90
Red drum (*Sciaenops ocellata*)	600	91	(1)		14,200	1,934	193,400	29,718	32,100	4,712	98,800	15,468	580	127	339,680	52,050	.93	.51
Crevalle jack (*Caranx hippos*)	3,600	103	4,900	152	96,200	2,901	94,400	2,529	16,300	327	53,300	1,454	1,320	76	270,020	7,542	.74	.07
Gray snapper (*Lutjanus griseus*)	25,300	6,583	100,400	25,382	3,000	562	59,800	10,760	5,200	969	46,100	7,707	5,600	1,625	245,400	53,588	.67	.53
Sheepshead (*Archosargus probatocephalus*)	2,100	227	100	12	17,900	1,705	66,300	6,057	23,300	1,977	32,400	2,798	1,340	198	143,440	12,974	.39	.13
Mojarra (*Various species*)	(1)				2,500	242	39,800	3,478	35,400	3,013	15,700	1,420			93,400	8,153	.27	.08
Sand seatrout (*Cynoscion arenarius*)					11,200	1,130	26,900	2,404	2,000	239	15,400	1,657			55,500	5,430	.15	.05
Gulf menhaden (*Brevoortia spp.*)					26,300	525	18,100	764			2,200	167			46,600	1,456	.13	.01
Black drum (*Pogonias cromis*)	100	10	(1)		8,800	430	11,700	603	6,200	288	1,200	65	1,920	326	29,920	1,822	.08	.02
Spot (*Leiostomus xanthurus*)	(1)				400	42	8,000	631	6,300	497	600	45	20	4	15,320	1,219	.05	.01
Permit (*Trachinotus falcatus*)	400	35	900	99	1,300	146	3,700	407	200	21	3,600	404			10,100	1,112	.03	.01
Lane snapper (*Lutjanus synagris*)	1,100	207	4,700	817	(1)		100	31							5,900	1,055	.02	.01
UNCLASSIFIED:																		
For food	46,000	2,772	39,700	2,515	48,100	4,205	284,200	24,953	5,600	494	328,300	29,366	8,660	1,042	760,560	65,437	2.09	.64
For miscellaneous purposes	27,800	1,512	4,200	223	5,900	165	37,500	1,088			18,600	544	420	9	94,420	3,451	.26	.03
FINFISH TOTAL	2,070,100	343,941	533,400	102,238	1,981,800	215,566	7,108,100	912,156	1,515,900	146,491	3,908,600	546,025	269,200	42,634	17,387,100	2,309,051	47.79	22.67
SHELLFISH																		
Pink shrimp (*Penaeus duorarum*)	190,000	68,290	14,716,300	6,390,822	1,021,900	522,490	621,700	358,554	400	171					16,550,300	7,340,327	45.49	72.08
Blue crab (*Callinectes sapidus*)	(1)		300	55	70,900	6,553			781,300	55,603	768,900	54,728	3,440	978	1,624,840	117,917	4.47	1.16
Stone crab (*Menippe mercenaria*)	102,300	50,976	137,700	68,756	530,600	270,979	7,400	3,047					42,180	22,348	820,180	416,106	2.25	4.09
SHELLFISH TOTAL	292,300	119,266	14,854,300	6,459,633	1,623,400	800,022	629,100	361,601	781,700	55,774	768,900	54,728	45,620	23,326	18,995,320	7,874,350	52.21	77.33
GRAND TOTAL	2,362,400	463,207	15,387,700	6,561,871	3,605,200	1,015,588	7,737,200	1,273,757	2,297,600	202,265	4,677,500	600,753	314,820	65,960	36,382,420	10,183,401	100.00	100.00

* Weight as landed (may be whole or gutted); shrimp = heads on

+ Common names after Bailey, et al (1970)

(1) Less than 100 pounds

The greatest impact of alteration of natural drainage is the intensified effect of naturally recurring droughts. Heavy summer rains and an occasional hurricane flood the Everglades, but these sources of water are intermittent and less important ecologically than water flow from the north (Tabb, 1963, 1966; Idyll, 1969). The flora and fauna are adapted to naturally occurring droughts of about two years duration, but the periods of stress are prolonged when superimposed on reduced freshwater flow from the north. For example, the "hydroperiod," that portion of the year when marshes are flooded by fresh to slightly brackish water, formerly lasted nine months or longer in average years but now extends only from June to November on the average. This period is of prime importance to the production of commercial and sport fish, because only during this time is there adequate surface water for spawning and survival of forage species (Tabb, 1966).

The result of reduced freshwater runoff has been an increase in estuarine salinity. Estuarine areas such as Whitewater and Coot Bays were formerly of intermediate salinity (about 20 ppt) but now reach 40 ppt during the dry season in winter (Heald, 1970). In Florida Bay hypersaline conditions are more acute. Formerly, hypersalinity (up to 70 ppt—about twice normal seawater) occurred only during severe droughts but now exists for most of the year in some areas of the Bay (Tabb, 1963; Heald, 1970).

Commercial and sport fish production can be seriously reduced if such prolonged hypersaline conditions become widespread. Based on evidence provided in Emery et al (1957), Tabb (1963) suggested that more than half of the marine invertebrate species normally found in Florida Bay will either be killed or forced to migrate when salinity reaches 60-70 ppt. Tabb further noted that turtle grass (*Thalassia testudinum*), the dominant primary producer in Florida Bay, is severely limited at these salinities and concluded, "It is entirely likely that most of the desirable sport and commercial fish and shellfish will be run out of the region when salinity values of 60 parts per thousand or higher prevail."

Less severe increases in salinity such as that now occurring in Whitewater and Coot Bays may also reduce commercial and sport fish production. By allowing a continual increase in salinity, some of the most valuable qualities of the estuary are lost (Odum, 1970). One of the most significant is the loss of protective nursery areas for juveniles, as increased salinity allows entrance of additional marine predator species that would otherwise be excluded because of their intolerance of lowered salinity. Also lost are the means by which young fish and shrimp find their way into the nursery areas. Odum refers to these as the "salinity transport mechanism" and the "dissolved organic road map." By responding to salinity changes occurring during the tidal cycle, young pink shrimp with little swimming ability are able to take advantage of tidal currents to enter the estuary. By orienting towards waters high in organic content, such as that flushed from the estuary, young shrimp and fish are able to migrate into the nursery grounds.

Domestic and Industrial Pollution

Much of south Florida's estuarine zone is located in Everglades National Park, far removed from population centers, and is relatively free of man's domestic and industrial pollution (Kolipinski and Higer, 1969; McNulty, Lindall, and Sykes, 1972). In fact, water quality in estuarine waters of the Park and lower Biscayne Bay is considered comparable to surface waters of the United States in the early 1900's (DeSylva, 1970; U.S. Department of the Interior, 1971).

Other water bodies of south Florida have not fared so well. A prime example is the overenrichment now occurring in Lake Okeechobee, the heart of the region's freshwater resource. Owing to the channelization of the Kissimmee River, which drains into Lake Okeechobee, the Kissimmee basin has experienced large-scale marsh loss and has lost much of its capacity to absorb fertilizing materials during runoff. These elements are now transported directly into the Lake, which is predicted to become eutrophic within the next 5 to 10 years (Marshall, 1971). Also, on the densely populated southeast coast, large volumes of untreated or partially treated effluents from domestic, industrial, and agricultural sources are released into numerous canals causing an excessive population of coliform bacteria and also causing periodic plankton blooms (National Academy of Sciences, 1970). Such inadequate treatment of effluents is the general rule in most of Florida's municipalities, and detrimental effects on the estuary can be longlasting, even after abatement. For example, in northern Biscayne Bay pollution was abated in 1956, but several years later commercial and sport fishing had not improved. Many effects of pollution were still present (McNulty, 1970).

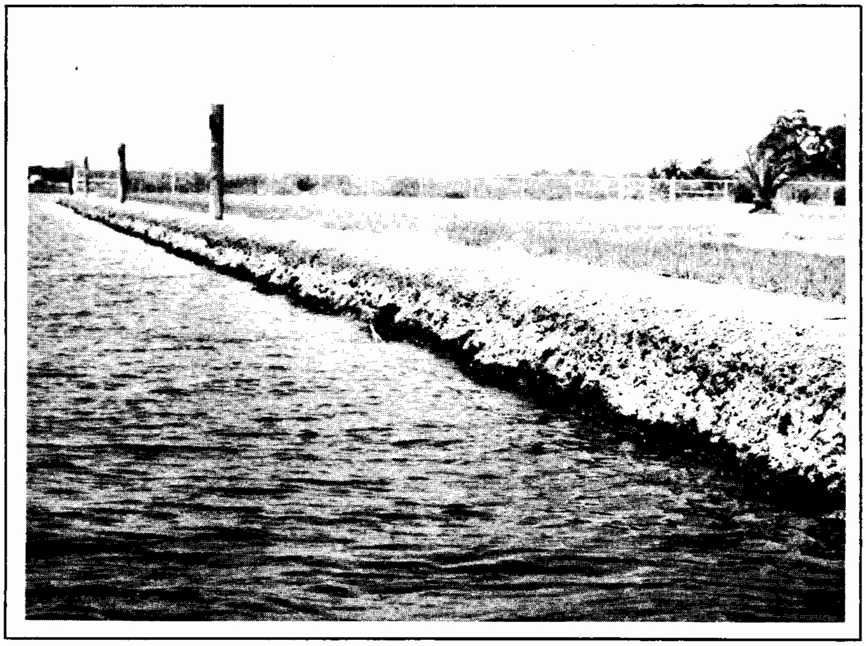
Pesticides

Evidence of pesticide contamination has been found even in pristine areas of south Florida. Surface waters in Everglades National Park contain an average of 0.02 μg/l of DDT and its metabolites, and sediments in the Shark River Slough and nearby canals contain concentrations 1,000 times greater than overlying waters. Mosquitofish (*Gambusia affinis*) in the same areas contain these pesticides in their tissues at a level of 4 orders of magnitude greater than the surrounding water (Kolipinski and Higer, 1969; National Academy of Sciences, 1970).

Presently, the effects of pesticides on the fisheries of south Florida are poorly understood, but the sublethal effects are known to be harmful. For example, DDT at sublethal levels can affect survival of some fish by reducing their ability to escape predation as well as affecting their ability to acclimate to thermal changes in the environment

(Above.) Example of a natural vegetated shoreline. Such waters provide valuable nursery areas for several kinds of fishes important in the sport and commercial catches.

(Right.) A similar area after bulkheading. Bulkheading is one of man's activities that can pose a threat to our estuarine areas.



(Odum, 1970). The latter effect is especially alarming in view of increased use of atomic-generated electric power with its concomitant increase in volume of heated water discharged into the estuarine ecosystem. Nationally, pesticides are already significantly reducing production of estuarine fish and shellfish (Butler, 1969 in Odum, 1970) and in combination with heated effluents from power plants, production of commercial and sport species could be reduced even further.

Thermal Addition

South Florida's climate is unique in the United States in that its land and fresh water are subtropical in nature, while its estuarine and marine waters are essentially tropical (Hoover, 1969). Typical air and water temperatures are between 26 and 31°C in the summer and between 15 and 25°C in the winter with an occasional frost (Idyll, 1969). In freshwater marshes of Everglades National Park, temperatures often reach 35°C during the summer and have occasionally gone to 38°C (U.S. Department of the Interior, 1971). Likewise, in shallow estuarine areas such as southern Biscayne Bay, August temperatures commonly exceed 35°C (Nugent, 1971). Life processes of fishes inhabiting these waters are geared to seasonal oscillations in water temperature, and many species are presently living within a few degrees of their upper lethal limit in the summer (Hoover, 1969). Thus, an increase of only a few degrees may easily reduce the survival rate of estuarine-dependent species.

Presently, little information is available on the ecological effects of thermal addition in estuaries, but studies in progress will help to provide needed data. In south Florida the effects of the Florida Light and Power plant at Turkey Point in southern Biscayne Bay are under study at this time. Until recently, this plant had two conventional units in operation that raised the daily average temperature across the condensor 5 to 6°C with a range from about 3°C in early morning to about 8°C in the evening (Nugent, 1971). Two nuclear units have been constructed at the site and are producing a limited amount of power. Because they are less efficient than conventional plants, it is expected that the average rise in temperature across the condensor will be 7 to 8°C when the nuclear plants are put into full operation (Roessler and Zieman, 1970).

Preliminary results of the Turkey Point studies showed heated effluent is degrading a portion of southern Biscayne Bay. Roessler and Zieman (1970) recorded a maximum summer temperature of 40.3°C near the outfall when ambient Bay temperatures were 31 to 32°C and found adverse effects over some 300 acres adjacent to the plant. Of these 300 acres, about 125 acres near the outfall and enclosed within the +4°C isotherm were severely affected; virtually all plants and animals were killed or greatly reduced in number. In the remainder of the affected area, enclosed within the +3°C isotherm, algae had been damaged and the number of fish reduced. In another study, Nugent (1971) described the effects of the heated water on the mangrove habitat through which the effluent flowed. Emphasis of this study was placed on the macrofauna, particularly the fishes. Nugent found that most fishes avoided the heated areas near the effluent canal except during the coldest weather. Gray snapper, the most abundant fish taken in the study, and tarpon (*Megalops atlantica*) exhibited the least response to increase in water temperature of any of the fish. No difference in numbers of these two species could be attributed to operation of the plant. However, other commercial and sport species including the white mullet (*Mugil curema*), fantail mullet (*M. trichodon*), striped mullet (*M. cephalus*), and 3 species of snook (*Centropomus undecimalis, C. pectinatus,* and *C. parallelus*) were taken in greatest numbers at the control station during warmer seasons. Kills of blue crab (*Callinectes sapidus*) and grunts (*Haemulon* spp.) occurred in the main discharge canal, and in June 1969, the normally hardy toadfish (*Opsanus beta*) succumbed in the offshore area. The only fish found consistently more abundant in the heated water was the lemon shark (*Negaprion brevirostris*).

Not all of the effects of heated discharge from the Turkey Point plant were detrimental. Some protection was afforded to fishes from a cold kill in January 1970, and sportfishing improved in some areas during the winter owing to increased availability (Nugent, 1970). These benefits, however, are not sufficient to offset the many detrimental effects of thermal addition.

Another and potentially more serious threat to estuarine-dependent fisheries is entrainment of planktonic organisms, including fish eggs and larvae, in the cooling system of the power plant where they are subjected to sudden increase of temperature and marked changes in pressure and turbulence (Nugent, 1970). The degree to which organisms are affected depends on the species present and individual plant design, but a recent study of the Turkey Point plant showed that zooplankton, especially those important in the food chain of Biscayne Bay, were extremely susceptible to damage. Some 80 to 85 percent of the zooplankton passing through the plant in July and August, 1970 were killed, and the abundance and distribution of benthic diatoms, the dominant phytoplankton in the Bay, were affected by the heated effluent (Prager, 1970). With the use of less efficient nuclear plants, more cooling water will be required, and the problem of entrainment will be more acute.

Dredging and Filling

Much of south Florida's estuarine zone lies within the boundaries of Everglades National Park and has thus far been spared the consequences of dredging and filling. However, many prime fish producing areas outside the Park, such as the Keys and a large portion of the Ten Thousand Islands, are in private ownership and are subject to alteration. The recent and often illegal destruction of the Keys for trailer parks, subdivisions, and waterfront homesites is symptomatic of runaway development. The phenomenal growth of south Florida's coastal communities will undoubtedly bring even more pressure to develop areas outside the Park.

The effects of dredging and filling are almost inevitably adverse and may be permanently destructive to the estuarine environment. Odum (1970) summarized generalized effects of this type of development and pointed out that about three acres of submerged bay bottom are required to create one acre of filled land. Destruction is, therefore, not limited to only the bottom covered by the fill. Areas from which the fill material is taken are often dug to depths below the photic zone; thus, light-requiring benthos are unable to exist. Moreover, silt, sewage, and other pollutants readily accumulate in the dredged depressions, and the resulting anoxic conditions at the bottom have a permanent adverse effect on aquatic life. Studies by Taylor and Saloman (1968) of dredging and filling in Boca Ciega Bay, Fla., showed that sediments in dredged canals averaged 92 percent silt and clay, whereas sediments in undredged areas averaged 94 percent sand and shell. Soft sediments in the canals contained large quantities of organic muds that reduced oxygen levels, and even after 10 years very little recolonization by benthic forms took place. Loss of fishery products from Boca Ciega Bay as a result of dredging and filling was estimated at 73 metric tons (80 short tons) per year. Another example of permanent adverse effects of dredging is found in Biscayne Bay. A deep area dredged in the south part of the Bay almost three decades ago is anoxic and barren today, even though little sewage presently enters the Bay (Odum, 1970).

Building a bulkhead along a vegetated shoreline and filling the vegetated area behind the wall comprise another method used to create waterfront real estate. This method is common in Galveston Bay, Texas (Mock, 1966), and is a lucrative one for developers of the mangrove-lined shores of south Florida. Such alteration leads to elimination of the intertidal zone along the marsh and mangrove—frequently the most productive portion of the estuary. Adjacent, shallow, subtidal areas are also often eliminated, because sediment is pumped from them to provide fill material behind the bulkhead or to create channels for boat traffic to and from deeper water (Odum, 1970). Mock (1966) compared a bulkhead area with a natural shoreline in Galveston Bay and found that both areas were similar in hydrology and sediment types, but that the natural area supported several times as many shrimp as did the altered area. He concluded that the difference was due to the physical alteration of the habitat which eliminated a natural band of organic detritus, reduced the organic content of the sediment, and deepened the water. Construction of bulkheads in south Florida would have similar effects and would undoubtedly seriously affect commercial and sport fisheries in the region by destroying nursery grounds of many species.

Public indignation over indiscriminate dredging and filling of our estuaries has produced recent legislative action to conserve and protect natural resources that remain (Bellinger, 1970; Linton and Cooper, 1971; McNulty, Lindall, and Sykes, 1972). Faced with statutory restraints, developers are devising alternate methods of creating waterfront home sites to satisfy public demand. One method is the construction of access canals leading from upland acreage to open water. As with bayfill canals, these upland canals are often designed without regard to fish and wildlife resources. Most are constructed with dead ends and dug to depths below the photic zone which create stagnant pockets of stratified water that are at times uninhabitable for fishes because of the lack of dissolved oxygen (Lindall, Hall, and Saloman, 1973). Such waters additionally create public health hazards that threaten adjacent estuarine areas and underground water supplies. For example, in a recent study of saltwater canals in the Tampa Bay area ranging from Weeki Wachee south to Punta Gorda, a majority of the canals were found to contain populations of coliform bacteria and *Clostridium perfringens*, the common cause of gas gangrene, in excess of federally approved State standards for body contact (Barada and Partington, 1972). In the same report, data and comments regarding conditions of canals in south Florida indicated:

1. Broward County - " . . . practically every canal in the county will exceed state standards for coliform contamination and, therefore, are unsafe for body contact."

2. Dade County - "Health problems can be expected in many of Dade's waterways . . . records show high MPN counts in many waterways. Several lakes have received much publicity because of eutrophication. With ideal conditions some of the blue-green algae can become toxic to animals. So far, there have been no records of human deaths. Reports of skin rash have been noted . . . Botulism, type C, is common in Dade County. Many birds have been killed by this toxin. Health problems occur with the occurrence of dead fish and animals in public waterways . . . Fish taken from Dade's canals at times appear to be undesirable for eating. Proper cooking should eliminate any danger involved, although the taste may be somewhat unpleasant (muddy)."

CONCLUSIONS

The estuarine zone of south Florida is a living, dynamic system made up of extremely complex interactions of wind, rainfall, freshwater runoff, tides, temperature, salinity, currents, sediments, nutrients, and fauna and flora. Cyclic floods, drought, and fire have periodically affected the ecosystem, but it has responded with remarkable resiliency, and the flora and fauna have adapted to such change. Physical and chemical alterations by man have compounded the natural stresses, however, and thereby greatly modified the natural processes to which the fauna have adapted. Among the fauna threatened by the changes are the estuarine-dependent marine fishes that support multimillion dollar commercial and sport fisheries.

Though much remains to be learned of the dynamics of the estuaries, the value of the ecosystem, economic and aesthetic, is now recognized, and steps are being taken to conserve vital areas. Especially encouraging are proposals at the State and National levels for purchase of the Big Cypress watershed to insure an adequate water supply to a portion of the Everglades National Park. To insure protection of other south Florida estuarine areas, however, present statutes prohibiting further alteration of estuaries and shoreline must be rigorously enforced. If alterations of the estuarine ecosystems with their dire consequences are allowed to continue in south Florida, as they have in the past, the fish resources of this region will continue to be threatened.

ACKNOWLEDGEMENT

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